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Osseointegration

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Abstract

Dental implants are becoming an increasingly popular alternative treatment for replacing missing teeth. Instead of using a bridge that spans between teeth, a permanent replacement tooth is attached to an implant in the mandible or maxilla. Radical changes in the practice of implant dentistry have been made possible through the evolution of a more profound understanding of the essential requirements of individual case treatment planning, improvements in surgical procedures, and the evolution of the design of the implants. However, the most fundamental process that is the basis to any implant treatment is osseointegration. A thorough knowledge of the mechanism of osseointegration and the various factors influencing it, will go a long way in optimizing the results obtained during implant therapy. This article aims at throwing light on the mechanism of osseointegration and the factors affecting it.

Key Words
Osseointegration, Bridge, Spans, Redical, Implant

Introduction

Osseointegration can be defined at multiple levels: clinically, anatomically, histologically, and ultrastructurally. It is defined according to the Glossary of Prosthodontic terms as “The apparent direct attachment or connection of osseous tissue to an inert, alloplastic material without intervening connective tissue”. A structurally oriented definition was put forth by Branemark and his associates in 1977. They defined osseointegration as the “Direct structural and functional connection between the ordered, living bone and the surface of load carrying implants”. Alberktsson et al, defined it as direct anchorage of an implant by the formation of bone directly on the surface of an implant without any intervening layer of fibrous tissue. This definition gave a histological perspective to osseointegration. Shroeder and his colleagues termed the process as being one of ‘functional ankylosis’.

The scope of osseointegration in the field of oral and maxillofacial prosthetics is immense. Prosthetic replacement of missing teeth, rehabilitation of complex maxillofacial defects, congenital defects such as cleft palate or ectodermal dysplasia and distraction osteogenesis to aid in the formation of new bone are all possible with implants having a direct connection to osseous tissue.

The concept of osseointegration was first put forth by Per-Ingvar Branemark in the year 1952. He discovered that bone can integrate with titanium implants. He termed this phenomenon osseointegration based on the Latin word ‘os’ which means bone and integrate which means ‘to make whole’. The concept has evolved as much into a philosophy as it is a technique for rehabilitation.

It must be emphasized that rehabilitation with implants would be impossible if the connection were a fibrosseointegration rather than osseointegration. The American Academy of Implant Dentistry in 1986, defined fibrous integration as tissue to implant contact with interposition of healthy dense collagenous tissue between the implant and bone. It was assumed that collagen fibers function similar to the Sharpeys fibers in the natural dentition. However, the fact is that there are histological difference between the Sharpeys fibers and collagen fibers around the implant. Unlike the natural teeth which have oblique and horizontal fibres, those around the implant are parallel, irregular and completely encapsulate the implant. This interferes with normal load transfer drastically. The end result is an inability to transfer loads and a possibility of infection. Thus, osseointegration, as a rule, should be the goal as opposed to fibrous integration.

Osteogenesis:

Osborn and Newsley, described the phenomenon by which bone can become juxtaposed to an implant surface. They described that this could occur via two means, either by contact osteogenesis or distance osteogenesis[1].

In distance osteogenesis, new bone is formed on the surfaces of old bone in the peri-implant site. The bone surfaces provide a population of osteogenic cells that lay down a new matrix that encroaches on the implant. The new bone is not forming on the implant, but the latter does become surrounded by bone. Thus, in these circumstances, the implant surface will always be partially obscured from bone by intervening cells.

In contrast, in contact osteogenesis, new bone forms first on the implant surface. The implant surface has to become colonized by bone cells before bone matrix formation can begin. Thus, distance osteogenesis results in bone approximating the implant surface while contact osteogenesis results in bone apposition to the implant surface.

Factors affecting osseointegration:

Numerous factors are known to influence osseointegration, some more strongly than others. Some of these factors are listed below:

1. Implant material and its biocompatibility
2. Loading protocols
3. Patient factors
4. Surgical technique and environment
5. Implant design

Implant material and its biocompatibility

Various materials have been employed in the manufacture of implants to date. However, use has mostly been restricted to metals, polymers and more recently, ceramics. Among the metals, titanium and its alloys have been the mainstay for implant manufacture. Tantalum and niobium have also been used although it has been reported that they elicit an exaggerated macrophage response. The popularity of titanium has been attributed to its chemical purity and its ability to form an adherent, passivating oxide film which forms at the rate of 100 Å per minute.

Titanium alloys, mainly Ti6Al4V, have been used successfully as they are stronger than Cp Ti. But with respect to osseointegration, Cp Ti is far superior to these alloys as it exhibits stronger bony interaction. The reason for this is that the aluminium ions from the alloy compete with calcium of the bone and impede osseointegration to a certain extent.

Hydroxyapatite coated implants have been in use for sometime now. Gottlander found an increased interfacial bone formation with hydroxyapatite coated implants as compared to CpTi for a short period while this was reversed in the long run with CpTi showing about 50-70% more bone formation[2].

Zirconia based implants have recently come into the market and are becoming more popular by the day. Studies show that although the osseointegration of these implants is not superior to titanium, zirconia implants with modified surfaces result in an osseointegration which is comparable with that of titanium implants[3].

Loading protocols

Implant loading can be classified as progressive loading or immediate loading. Progressive loading was recommended by Misch[4] in 1980. The concept was proposed to decrease crestal bone loss and early implant failure. It necessitated two surgical appointments - the first surgery for initial implant placement and the second stage surgery was done to uncover the implant and begin prosthetic treatment. The two stages are usually separated by a span of 3 to 8 months depending on the density of bone at the intial surgery. Progressive loading calls for increasing the load on an implant retained restoration gradually. Initially no load is placed on the implant. The transitional prosthesis is then placed on the implant and contact is provided only on the implant and not on the cantilevers. Later, the final prosthesis is delivered with an implant protective occlusion scheme. Several studies indicate excellent bone formation around progressively loaded implants[5],[6],[7].

Immediate loading protocols place a transitional prosthesis on the implant at the time of implant placement itself. Various approaches have been developed by different authors to achieve the same[8],[9],[10]

Clinical trials have shown successful osseointegration (95-100% success rate-Completely edentulous patients) in recent times.

Patient factors

The major factors which need to be considered during implant placement with regards to health of the patient are: age, previous irradiation and history of smoking,

Age

Extremes in age are relative contraindications to implant placement although old age has shown no poorer results. In children, placement of implants could lead to an infrapositioning of the implant following growth and needs to be considered during implant surgery. Early placement of implants may be required in cases which use bone anchored hearing aids.

Radiation

Previously irradiated bone is a relative contraindication to implant placement. It has been seen that success rates are 10-15% lesser in irradiated patients as opposed to non-irradiated patients. If the patient has been irradiated before implant surgery, the higher the dose, the poorer the results. The longer the time from radiotherapy, the poorer the results[11]. Jacobsson showed an increasing implant loss over time in irradiated patients in a long term study[12]. Hyperbaric Oxygen therapy has been found to improve osseointegration in irradiated patients as it elevates the partial pressure of oxygen in the tissues.

Smoking

Mean failure rates are twice as high in smokers as in non-smokers[13]. History of smoking affects the healing response in osseointegration adversely. Smoking causes vasoconstriction, a reduced bone density and impaired cellular function and thereby interferes with healing following implant surgery.

Surgical technique and environment: Minimal tissue trauma provides the best environment for successful osseointegration. A violent surgical technique leads to frictional heat being produced, a wider zone of necrosis and consequently a primary failure in osseointegration. Lundskog[14] determined cellular necrosis to occur following a 30s duration at above 50°C whilst Eriksson and Albrektsson[15] demonstrated that a temperature elevation to above 47°C which is sustained for one minute has a potent osteonecrotic effect. Profuse irrigation for continuous cooling, use of well sharpened drills and use of graded series of drills, slow drill speeds (<2000rpm), proper drill geometry and intermittent drilling are recommended to achieve predictable osseointegration.

Implant Design

Implant design refers to the three dimensional structure of the implant. Implants may be cylindrical or screw shaped. They may be threaded or non-threaded. Bone resorption has been associated with the use of press fit or cylindrical implants primarily due to micromovements that occur during their use. This problem is more or less eliminated when screw shaped implants are used. Threaded implants have a long documentation of successful use in dentistry. The advantage of threaded implants is that they provide more functional surface area for better load distribution. Furthermore, there is lesser micromovement seen in association with these implants.

Conclusion

Implant osseointegration is probably one of the most critical aspects in implant therapy. It is mandatory that osseointegration be successful in order that the implant treatment achieves its most important goal - the restoration of missing natural tissue. A thorough knowledge about the science behind this process will hold the dentist in good stead while dealing with restorative therapy involving implants.

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